CLAIMS

We Claim:

1. A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;

forming a first metal-containing dielectric layer over the surface, the metal comprising an element selected from Group IVB of the periodic table; and

forming a second metal-containing dielectric layer over the first metal-containing dielectric layer.

2. The method of Claim 1, wherein the first metal-containing dielectric layer comprises hafnium.

3. The method of Claim 1, further comprising:

forming a layer of silicon dioxide overlying at least one portion of the surface; and

wherein forming the first metal-containing dielectric layer comprises;

forming a metal layer over the layer of silicon dioxide; and

combining metal of the metal layer with oxygen of the silicon dioxide layer to form a metal oxide dielectric material.

4. The method of Claim 3, wherein the metal layer comprises hafnium.

5. The method of Claim 4, wherein the combining comprises providing conditions effective for the hafnium of the metal layer to chemically reduce the silicon dioxide layer.

6. The method of Claim 1, where the second metal-containing dielectric layer comprises an element selected from Group IIIB of the periodic table.

7. The method of Claim 1, where the second metal-containing dielectric layer comprises lanthanum.

8. The method of Claim 1, where the forming of the first metal-containing dielectric layer and the second metal-containing dielectric layer comprise:

forming a hafnium-containing layer;

forming a lanthanum-containing layer over the hafnium-containing layer; and

exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

9. The method of Claim 8, where forming the hafnium-containing layer and the lanthanum-containing layer comprises physical vapor deposition.

10. The method of Claim 8, where the exposing comprises ion bombardment of the first hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 electron volts (eV) or less.

11. The method of Claim 10 where the heating comprises heating to a temperature from about 200°C to about 400 C during the ion bombardment.

12. The method of Claim 8, where the exposing comprises positioning the substrate within a reaction chamber and exposing the hafnium-containing layer and the lanthanum-containing layer to oxygen radicals within the reaction chamber.

13. The method of Claim 8, where:

the forming the hafnium-containing dielectric layer comprises depositing hafnium to a thickness less than or equal to about 5 nanometer (nm); and

the forming the lanthanum-containing dielectric layer comprises depositing lanthanum to a thickness less than or equal to about 5 nm.

14. The method of Claim 13 comprising a ratio of the hafnium thickness to the lanthanum thickness of from about 1 to 3 to about 1 to 4.

15. The method of Claim 8, where;

the forming the hafnium-containing dielectric layer comprises forming a layer containing hafnium to a thickness of about 1 nm;

the forming the lanthanum-containing dielectric layer comprises forming a layer containing lanthanum to a thickness no greater than about 5 nm; and

wherein a ratio of thicknesses of the hafnium-containing layer to the lanthanum-containing layer is from about 1 to 3 to about 1 to 4.

16. The method of Claim 1, where the forming of the first and second metal-containing dielectric layers comprises physical vapor deposition.

17. The method of Claim 16, where physical vapor deposition comprises electron beam evaporation.

18. The method of Claim 1, where forming the first metal-containing dielectric layer and the second metal-containing dielectric layer comprises forming the layers to have respective thicknesses having a ratio of from about 4:1 to about 1:4.

19. The method of Claim 1, where the first metal-containing dielectric layer consists of hafnium oxide and the second metal-containing dielectric layer consists of lanthanum oxide.

20. A method for forming an MOS transistor, comprising:

providing a semiconductor substrate having a surface comprising silicon;

forming a hafnium-containing dielectric layer overlying the surface;

forming a lanthanum-containing dielectric layer overlying the hafnium-containing dielectric layer; and

forming a gate electrode over the hafnium-containing and lanthanum-containing dielectric layers.

21. The method of Claim 20, where:

the forming of the hafnium-containing dielectric layer dielectric layer comprises first forming a hafnium-containing layer;

the forming of the lanthanum-containing dielectric layer comprises second forming a lanthanum-containing layer; and

wherein the first forming and the second forming encompass physical vapor deposition.

22. The method of Claim 21, where physical vapor deposition comprises electron beam evaporation.

23. The method of Claim 20, further comprising forming a layer of silicon dioxide over at least a portion of the surface comprising silicon, prior to the forming of the hafnium-containing dielectric layer.

24. The method of Claim 20, where the forming of the hafnium-containing dielectric layer and the lanthanum-containing dielectric layer comprises :

first forming a hafnium-containing layer and second forming a lanthanum-containing layer over the substrate; and

exposing the hafnium and lanthanum containing layers to an oxygen comprising atmosphere while heating the hafnium and lanthanum layers to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

25. The method of Claim 24, where forming the hafnium-containing dielectric layer and the lanthanum-containing dielectric layer comprise forming oxides of hafnium and lanthanum, respectively.

26. The method of Claim 24, where the heating comprises heating the hafnium and lanthanum containing layers to a temperature from about 200°C and 400°C.

27. The method of Claim 25, where:

the hafnium-containing layer is formed over a layer of silicon dioxide; and

further comprising providing conditions effective for the hafnium-containing layer to chemically reduce the layer of silicon dioxide.

28. The method of Claim 25, further comprising:

providing ion bombardment of the hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 eV or less and where the heating to an effective temperature comprises heating while providing ion bombardment to a temperature from about 200°C to about 400°C.

29. The method of Claim 25, where:

the forming of the hafnium-containing layer comprises forming such layer having a thickness no greater than about 5 nanometers;

the forming of the lanthanum-containing layer comprises forming such layer having a thickness no greater than about 5 nanometers; and

wherein a ratio and a sum of the thicknesses of the hafnium-containing layer to the lanthanum-containing layer is from about 1 to 4 to about 4 to 1 and no greater than about 6 nm, respectively.

30. The method of Claim 29 where the thickness of the hafnium-containing layer is no greater than about 1 nm.

31. The method of Claim 29 where the hafnium-containing dielectric layer and the lanthanum-containing layer are collectively a gate dielectric layer, where the gate dielectric layer is formed having an equivalent oxide thickness less than or equal to 2 nm.

32. A method of forming a capacitor structure, comprising:

providing a first capacitor electrode;

forming a hafnium-containing dielectric layer overlying the first capacitor electrode;

forming a lanthanum-containing dielectric layer over the hafnium-containing dielectric layer; and

forming a second capacitor electrode overlying the hafnium-containing and lanthanum-containing dielectric layers.

33. The method of Claim 32, where:

the forming of the hafnium-containing dielectric layer comprises forming a hafnium-containing metal layer having a first thickness;

the forming of the lanthanum-containing dielectric layer comprises forming a lanthanum-containing metal layer having a second thickness; and

wherein a ratio of the first thickness to the second thickness is from about 1 to 4 to about 4 to 1.

34. The method of Claim 33 where the first thickness is no greater than about 1 nm and the ratio of thicknesses is from about 1 to 3 to about 1 to 4.

35. The method of Claim 33, further comprising, prior to forming the second capacitor electrode, providing an oxygen comprising atmosphere effective to essentially completely oxidize the hafnium-containing and lanthanum-containing metal layers.

36. The method of Claim 35, where providing the oxygen comprising atmosphere further comprises heating the hafnium-containing and lanthanum-containing metal layers to a temperature from about 200°C to about 400°C.

37. The method of Claim 33, where:

the providing the first capacitor electrode comprising providing a silicon-containing first capacitor electrode; and

prior to forming the hafnium-containing metal layer, forming a layer of silicon dioxide over at least a portion of the silicon-containing first capacitor electrode.

38. The method of Claim 37, where the hafnium-containing metal layer is formed overlying at least a portion of the layer of silicon dioxide; and

further comprising providing conditions effective for the hafnium of the hafnium-containing metal layer to chemically reduce at least a portion of the silicon dioxide underlying such layer.

39. An MOS transistor comprising:

a semiconductor substrate having a silicon-containing surface;

a gate dielectric layer comprising:

a first metal-containing dielectric layer contacting the silicon-containing surface, the metal of the metal-containing layer being selected from Group IVB of the Periodic Table of the Elements;

a second metal-containing dielectric layer contacting the first-metal-containing dielectric layer; and

a gate electrode overlying the gate dielectric layer.

40. The transistor of Claim 39, where the gate dielectric layer comprises an equivalent oxide thickness of less than or equal to 2 nm.

41. The transistor of Claim 40, where the second metal-containing dielectric layer is spaced from the silicon-containing surface by the first metal-containing dielectric layer.

42. The transistor of Claim 41, where the first metal-containing dielectric layer comprises hafnium and the second metal-containing dielectric layer comprises lanthanum and where the first metal-containing dielectric layer and the second metal-containing dielectric layer have a total thickness of about 6 nm or less.

43. The transistor of Claim 42, where the hafnium-containing dielectric layer has a first thickness and the lanthanum-containing dielectric layer has a second thickness, the second thickness being from about one fourth to four times the first thickness.

44. The transistor of Claim 39, where:

the first metal-containing dielectric layer is a hafnium-containing dielectric layer having a first thickness no greater than about 1 nm;

the second metal-containing dielectric layer is a lanthanum-containing dielectric layer having a second thickness of no greater than about 5 nm;

wherein a ratio of the first thickness to the second thickness is from about 1 to 3 to about 1 to 4; and

the gate dielectric layer has an equivalent oxide thickness of less than or equal to 2 nm.

45. An capacitor structure comprising:

a first capacitor electrode;

a capacitor dielectric layer comprising;

a hafnium-containing dielectric layer contacting the first capacitor electrode;

a metal-containing dielectric layer contacting the hafnium-containing dielectric layer, the metal of the metal-containing dielectric layer selected from Group IIIB of the Periodic Table of the Elements; and

a second capacitor electrode overlying the metal-containing dielectric layer.

46. The capacitor structure of Claim 45, where the metal-containing dielectric layer is spaced from the first capacitor electrode by the hafnium-containing dielectric layer.

47. The capacitor structure of Claim 45, where:

the hafnium-containing dielectric layer has a first thickness;

the metal-containing dielectric layer comprises a lanthanum-containing dielectric layer having a second thickness; and

wherein a ratio of the first thickness to the second thickness is from about 1 to 4 to about 4 to 1.

48. The capacitor structure of Claim 47, where the ratio is from about 1 to 3 to about 1 to 4.

49. A memory integrated circuit comprising a transistor and/or a capacitor formed employing a dielectric layer consisting of hafnium oxide, lanthanum oxide and/or mixtures thereof.

50. The memory integrated circuit of Claim 50 comprising a DRAM or an SRAM integrated circuit and the dielectric layer is a gate dielectric layer.

51. The memory integrated circuit of Claim 50, where the gate dielectric layer has an equivalent oxide thickness less than or equal to 2 nm.